Teachers' Collaboration in a Mathematics Lesson Study

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We aim to understand how primary teachers who participated in a lesson study developed their collaboration relationships. The research is qualitative and interpretive with a case study design. The results show that the involvement in moments of planning and analysis of the students' work, where teachers reflected on practice and for practice helped them to develop collaborative relationships, moving from storytelling and scanning to joint work. The teachers were encouraged to express their voices regarding their participation in the lesson study and this led to an increasing involvement in the group, favoring the development of their reflection and knowledge of mathematics teaching.

Keywords: Lesson study, collaboration, reflection, professional development

Introduction

Lesson study is a professional development process widely practiced in many countries around the world. Teachers work in a collaborative way on a curriculum topic or issue related to students' learning, study curriculum documents and teaching materials, and plan and teach a research lesson which is then object of reflection (Fujii, 2016; Lewis, 2016; Takahashi & McDougal, 2018). During the lesson, taught by one of the teachers, the participants observe the events and afterwards analyze students' learning, emerging difficulties, and possible alternatives to consider. In lesson study, the discussions held by the group elicit, challenge and question the conceptions and practices of teachers (Cajkler, Wood, Norton, Pedder & Xu, 2014; Fujii, 2016). This collaboration provides teachers opportunities to run risks in their practice and to try new ideas in a structured and supported way, with focus on students' learning (Fujii, 2016).

Collaboration is central in discussions about teachers' professional development. According to Fullan and Hargreaves (1992), for change to occur in the classroom, teachers must be encouraged to collaborate with their colleagues in a learning community. Ponte (2012) suggests that teachers learn through their activity and the reflection that they make on that activity and such learning depends both on their personal commitment and collective support. However, a recent survey on collaboration made for ICME 13 (Robutti et al., 2016), showed that very little is known about the dynamics that take place in collaborative processes. Therefore, the aim of this paper is to understand how collaborative relationships among teachers may develop in a lesson study.

Collaboration

In collaboration, teachers work together aiming to achieve a common goal, negotiating working processes and making decisions together (Boavida & Ponte, 2002; Menezes & Ponte, 2009; Robutti et al., 2016). Research on teachers' professional development has pointed out the benefits of joining teachers and researchers in collaborative processes (Boavida & Ponte, 2002; Hollingsworth & Clarke, 2017). The role of participants may be distinct, as the important point is that they work in horizontal

relationships so that there is mutual support to achieve the common goals of the group (Boavida & Ponte, 2002). When involved in collaborative processes focused on their own practices, teachers work with more experienced colleagues and with researchers, they may develop new knowledge, which is in their zone of proximal development (Blanton, Westbrook & Carter, 2005).

Little (1990) distinguishes four kind of professional relationships among teachers, with different nature and potential: (i) storytelling and scanning for ideas; (ii) aid and assistance; (iii) sharing; and (iv) joint work. Storytelling and scanning for ideas corresponds to interactions among teachers that are occasional and stand on opportunity, where teachers seek to obtain specific ideas, solutions, or confirmations in brief exchanges of experiences in informal settings. In aid and assistance, teachers expect to get support from their colleagues in solving problematic situations. This relation is unidirectional and unequal and keeps the individual teacher as the sole decision maker. Sharing takes place by the exchange of resources, methods, ideas and opinions, and necessarily involves some level of exposition of the teacher regarding his/her colleagues. Finally, joint work occurs "among teachers that rest on shared responsibility for the work of teaching (interdependence), collective conceptions of autonomy, support for teachers' initiatives and leadership with regard to professional practice, and group affiliation grounded in professional work" (Little, 1990, p. 519). This form of collaboration requires much responsibility, commitment, and time from the participants but has stronger potential for solving problems and developing knowledge in a group that seeks to improve teaching practice. The work developed in the lesson study is intended to be collaborative and, in this way, in this research we analyze the interaction of the group according to the four kinds of relationships stated by Little (1990).

Methodology

This research is qualitative and interpretative (Erickson, 1986), based on a group of teachers who participated in a lesson study in 2013-14, in a school in Lisbon. This lesson study originated in a request from the school principal to support a project to improve students' results in mathematics. Seven teachers were appointed by the principal but, after five sessions, only three (Irina, Manuela, Antónia, fictitious names) remained in the group. Several teachers gave up indicating little interest in the activity or other personal reasons. The three participating teachers had between 10 and 15 years of experience and all had initial teacher education as primary teachers. However, Irina had a specialization in teaching Mathematics and Science and Manuela in teaching Portuguese and French. Our team included the two authors, another reasearcher and an assistant for data collection. We directed all sessions, leading the planing and assuming the role of experts in the post-lesson reflection. We sought, essentially, to center the work of the group in the exploratory approach (Ponte & Quaresma, 2016), with special attention to the tasks to propose to students, students' reasoning, and classroom communication processes.

The lesson study had twelve sessions. Session 1 included the introduction of participants, the establishment of the general work program and the definition of the topic to address. Sessions 2 to 4 were dedicated to study the topic and the exploratory approach and sessions 5 and 6 to the planning of the research lesson. Session 8 was the research lesson and session 9 the post-lesson reflection. In sessions 10, 11 and 12, which we called "follow-up", the teachers planned, carried out and reflected on two lessons that they made, as a way to deepen the work undertook before. After the post-lesson reflection, we made an individual semi-structured interview to each teacher and in the last session we made a focus group

interview, asking the teachers to reflect on the lesson study and the work developed, on the various aspects of the exploratory approach and on the work of students. Two main adaptations from the usual Japanese model were made in this process: (i) setting up a collaborative environment, including teachers and researchers, from the beginning to the end of the lesson study; and (ii) follow-up sessions, that allowed teachers plan new lessons together, addressing new topics, putting into practice what they learnt in previous sessions, and reflecting on the results. Data where gathered by participant observation through the undertaking of a research journal (elaborated by a researcher and completed by the others), audio recording of working sessions (designated as S*x*), with transcriptions, and video recording of the research lesson, and individual interviews to participant teachers (E). Data were analyzed in an inductive way, taking into account the four teachers' forms of interaction indicated by Little (1990): (i) storytelling and scanning for ideas; (ii) aid and assistance; (iii) sharing; and (iv) joint work.

First part of the lesson study

Study of the topic and of the exploratory approach

In session 1, taking into account students' difficulties, it was decided that the topic to study would be addition and subtraction of fractions by juxtaposing of line segments. Sessions 2 to 5 addressed mathematical and didactical issues relevant to teaching and learning this topic. Therefore, in session 2, the group solved tasks and identified students' difficulties. In session 3, there was a discussion about students' current knowledge and a diagnostic worksheet for the teachers to carry out in their classes was elaborated. In session 4, the responses of the students were analyzed, taking into account the nature of tasks, seeking to identify generalizations and justifications and surprising features in students' responses. In session 5, possible generalizations in addition and subtraction of rational numbers were identified. The main ideas related to the exploratory approach were discussed in depth: using challenging tasks, supporting students' reasoning, figuring out strategies to solve problems and making generalization and justifications, and promoting students' communication of their ideas with particular attention to whole class discussions. During these sessions, Irina had a very active participation working jointly with the researchers but Manuela and Antónia participated very little, interacting in aid an assistance way with the group. One perturbing factor of the group dynamic in this phase of the work was the reluctance of all teachers to assume the role of teaching the research lesson. This situation was finally overcome in session 5, when it was decided that Irina would take that role. She made de initial draft of the lesson plan that was discussed in session 6.

Post-lesson reflection and interviews

The post lesson reflection was carried out in session 9 as a reflection on practice. The group agreed that Irina prepared well the research lesson and its enactment corresponded very well to the planning. Some video excerpts from the lesson, representing students' strategies and difficulties, were analyzed. We made several challenges to the teachers, but only Irina sought to respond to them. When questioned, Antónia and Manuela, only described the events to support the judgments made by other participants. In a quite reserved stance, they narrated observations that they made during the lesson and supported the group in forming a general idea about the lesson participating in an aid and assistance way and storytelling and scanning for ideas. In contrast, Irina shared with the group her ideas and opinions (joint work). However, during this analysis of students' difficulties, she seemed

to feel unease, assuming that her work was being criticized.

After this post-lesson reflection we made individual interviews to the teachers. Surprisingly, these interviews turned out to be quite deep reflections about the work previously carried out in the lesson study. Irina made a deep reflection of the activity carried out in the former sessions, including the research lesson. Manuela and Antónia, indicated the reasons why they were not much involved in the sessions: Manuela felt difficulty in understanding much of the mathematical discussions that went on and felt insecure in participating and Antónia found the analysis of students' strategies and difficulties too detailed. The expression of feelings and difficulties by the teachers, in a relationship of great confidence with the researchers, created a completely new working environment.

Follow up

Planning

In session 10, we asked teachers to plan a lesson that they would be teaching, taking into account the work carried out before. Manuela suggested that they could plan a lesson together and that she and Antónia could teach it, instead of Irina that had made much work previously.

> And why we do not the following: we give Irina a break, we plan [together with Marisa], I and Antónia [make the tasks in our classes] and present them [in the next session]? And you [Irina] may use them later in your class. (S10).

In this way, Manuela recognized that she and Antónia were not much active in their participation in the previous phase of the lesson study. Now, she was willing to assume an active role. This shows that she felt more confident with what she learnt in the previous sessions. It was then decided that both teachers would use the tasks in their classes and Irina would support them in reflecting about the results to present and discuss in the next session. In this way, the three teachers prepared a lesson about the relationship between fractions and decimals in a setting of shared responsibility of planning a lesson in joint work.

However, Antónia and Manuela begun their planning quite insecure. They opened the textbook and began to scan different pages. It was noticeable that they were uncomfortable with the perspective of picking tasks from the textbook, perhaps as they thought that we would not find that much appropriate. Taking into account the struggle of the teachers, Marisa suggested that, instead of selecting a task, they could adapt it. Manuela agreed: "I think so, increasing the difficulty, isn't it? Because that one is very basic. But I think yes, mixing up tenths, hundredths and thousandths, with different denominators" (S10). At that point, Antónia and Irina also began giving suggestions and registering more ideas to elaborate the task:

Antónia:	Or A, B and C, in order to have two equivalent and one different.
Irina:	Ah, yes.
Antónia:	For example, to have two equivalent fractions. They understand that . . . Are equivalent fractions, albeit having different denominators.
Manuela:	Why we do not give a hypothesis here… That is, why do not give equivalent fractions?

Marisa: Ah, one of these being as a fraction. Yes, instead of all being as decimals . . .

Manuela: For example, here are four as decimals, isn't? And one in words. Why we do not take out that is in decimal and put it in fraction?

Irina: Exact.

Marisa: May be.

Irina: And then, during the discussion, we can ask them to write this also as a fraction. (S10)

So, in joint work, the teachers constructed the first question of the task (Figure 1):

1. In the squared paper, paint 0.4 in green; 40/100 in blue and "four hundredths" in yellow.

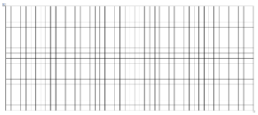

Figure 1: Task elaborated by the teachers in session 10

Irina went on providing suggestions, Manuela was much more participative and engaged than usual, and Antónia, albeit less participative than the colleagues, was also involved, contrarily to what happened in former sessions. This session witnessed two important aspects. The first is the change in attitude of Manuela and Antónia that began to assume strong participation in the common activity. This change seemed to result from the confidence that was established in the group after the interviews. The second aspect is the difficulty of the teachers in assuming an authorship role and a critical stance regarding tasks. This difficulty, however, was overcome with our suggestion of adapting tasks. It seems that the work carried out in the lesson study brought the teachers towards a point in which they were ready to assume this way of working, only with minimal support of a more experienced partner.

Reflection

In session 11, the three teachers reflected on their classroom experience in carrying out the task prepared in session 10. Antónia reported that her students had many difficulties in solving the first question:

> Mine, I only had one that was able to make everything right. A group. Then, I had three more that could make one part right and another wrong, they made well the four tenths, but then the forty hundredths, which corresponded to the same thing, they did not. And that is it. I think that they had here several squared that confused them. (S11)

Antónia tried to understand the difficulty of the students and suggested that they could got confused by having squared paper to represent the numbers indicated. She suggested that may have led the students to "not understand what the unit was" (S11). She showed surprise and frustration with the difficulties of her students: "they already know this well . . . They know how to transform decimals in fractions and fractions in decimals" (S11). The other teachers tried to find an explanation for the difficulty of her colleague: "I think that the fact that this looks visually different, it is only enough that one is as a decimal and the other as a fraction, this is enough to prevent them of seeing something that is equivalent" (S11). Seeking to find reasons for the students' difficulties, still in a superficial

way, Antónia referred that they forgot what they knew, whereas Manuela focused in the differences between fraction and decimal representations.

In the sequence, Manuela also presented her analysis of the work of her class. All students had the question on the painting of 0.4 correct but failed the next questions. In response, Antónia pointed out some similarity in the results of the two classes: "Here, there is something more or less similar. My [students] that got some [questions] right, the green [0,4], which was first. After that…" (S11)

Irina also tried to find a reason for the difficulties of the students, referring that "from the moment in which we begun to work with decimals, fractions become in trouble" (S11). She considered that the work with decimals led the students to forget about fractions. Up to this point, the teachers were still scratching the superficial features of the issue.

Taking into account that most students failed in representing the hundredth part of the unit, Manuela suggested that this mistake was related to visualizing the hundredth part of the picture that they were shown, in contrast with the visualization of tenths: "Here they visualize very well the tenth parts" (S11). Irina agreed, saying: "the hundredth is not easy for them to see. It is not intuitive" (S11). That is, Manuela began to base her analysis of the strategies of the students noting an important constrain related to the material that they received, which is a quite interesting reflection.

As the difficulty of the students was identified, Irina reflected on her own practice, notably on the work that she usually does concerning the representation of decimals:

> When we speak of the tenth, usually we use a bar divided in ten. Then, suddenly, we start speaking of the hundredth, and the unit instead of being the bar with ten, becomes a square with one hundredth. And, suddenly, we begin to speak of the thousandth, and we get this. Therefore, the unit that is always one, change its form. And that messes up the students in an extraordinary way. (S11)

Irina identified a problem of her practice as she considers that the way she presents the submultiples of the unit to the students does not facilitate their understanding of the unit and of that relationship with the submultiples. All participants agreed with Irina, that decided to take the discussion one step further, challenging the group to think in a solution for the problem: "But, and now? This is a reflection. What do we do?" (S11). She went on, pointing that the representation requires that students really understand the decimal number system and what the unit is.

In the sequence of the discussion, Antónia suggested to her colleagues that they could do the same way she did in the discussion of the task, cutting the rectangle in 10, 100, and 1000 parts and Irina agreed. In addition, Manuela referred the need of the students to have flexibility to interpret other representations. Irina concurred but underlined the importance of changing their practice making an initial work consistent with the rectangle representation, as a basis to later understand more simplified representations of the unit. This discussion was mediated by Marisa, who raised questions. But the teachers themselves developed a deep reflection about her own teaching practice, questioned the solutions and difficulties of the students and tried to find explanations for what happened, analyzing with much detail the origin of the difficulties. The teachers did not limit themselves to trying to understand the problem, they sought to overcome it in a reflection for practice. Irina continued to show a strong inclination to carry out the reflection further, proposing well-grounded solutions, and Manuela

and Antónia had a strong participation, with a great engagement in analyzing students' learning in relation to their practice. The change in attitude of Antónia and Manuela led the group to a join work mode, in which all participants were involved in a common activity.

Discussion

During the lesson study, we challenged the teachers in different ways. Irina, who taught the research lesson and was very confident in mathematics teaching, was always much involved in all activities. From very early, she worked jointly with us in constructing an exploratory task for the research lesson, in order to favor students' learning and understanding. The post-lesson reflection was carried out in a frame of joint work between Irina and the researchers. However, Manuela and Antónia were little involved in the activities remaining in the mode of storytelling and scanning for ideas.

In the follow-up sessions, all teachers were called to plan, teach and reflect about two lessons. Manuela and Antónia become very active and participating. They were going now to teach their classes with their own students and no observers. However, the main reason for this active participation was the reflection that they made in the interviews, in which they assumed a very personal voice regarding their development trajectories. This key importance of teachers' voice in collaborative processes is also underlined in Robutti et al. (2016). With the support from Irina, they felt confident to adapt tasks from the textbook and make them more challenging for their students. In the lesson study, they appeared to have developed new knowledge, which was in their zone of proximal development (Blanton, Westbrook & Carter, 2005). Therefore, from this point on, all group (teachers and researchers) begun to work jointly, sharing a common responsibility for the work.

Conclusion

This lesson study, favored the development of joint work among the participants and that led them to get involved in reflecting about their own practice and the way students learn. Such reflections are important levers for professional development. During the follow-up, the work carried out favored the creation of an environment of integration of knowledge (Lewis, 2016), in which teachers constructed actively their knowledge by designing tasks and collecting data from their students, establishing connections among different data sources. This has largely resulted from the possibility that the teachers had to express their voice and individuality and the challenges and responsibilities that they progressively assumed, namely the responsibility for the decisions of the group, for the materials produced, in particular for the selection and elaboration of challenging tasks and the preparation of the lesson plans that all teach. With this, they identified problems in their practice and created solutions with strong rationales. This evolution only occurred when the teachers felt confident to question their conceptions and practices and to try out new ideas (Cajkler et al., 2016; Fujii, 2016; Ponte, 2012). The follow-up sessions were much important to bring together the members of the group. The fact that all teachers taught and reflected on two lessons at this phase led them to get more involved and with more responsibility in the development of the work, suggesting the value of all participants teach a lesson and share that experience with the group. Other modifications in the format of a lesson study, such as teaching and reflecting on a pilot lesson during the planning, may contribute to similar results. This and other adaptations are to be experimented in order to take the most out of this professional development process, taking into account the local culture of the participating teachers.

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